Report for 2005DC73B: Air-Deposited Pollutants in the Anacostia River Watershed

Publications

- There are no reported publications resulting from this project.

Report Follows

AIR-DEPOSITED POLLUTION IN THE ANACOSTIA RIVER WATERSHED

Annual Progress Report for FY 2005

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PROGRESS REPORT: AIR-DEPOSITED POLLUTION IN THE ANACOSTIA RIVER WATERSHED

The project Air-Deposited Pollution in the Anacostia Watershed aims to focus on the characterization of the contribution of aviation efflux to the adverse environmental poisoning of the Anacostia watershed. The combustion of aviation fuel leads to the build-up of nitrogen oxide (NOx) or airborne nitrogen. The investigation is complicated by, among other things, the breakdown or combination of aviation chemical aerosols with other chemicals in the air during the transport process. The diffusion and transport of these airborne pollutants and their eventual deposition in the watershed can be accomplished via wet and dry deposition mechanisms.

Airborne pollutants that fall to the earth's surface may be transported into streams, rivers, and the Anacostia River by runoff or through groundwater flow. A Technical Report titled: Fine Particles and Oxidant Pollution: Developing an Agenda for Cooperative Research by George M. Hidy, et al describes a background for the North American Research Strategy for Tropospheric Ozone (NARSTO). It suggests that airborne particles are suspended in complex mixtures of gases, including oxidants produced from photochemical reactions of VOCs and NOx.

These aerosols occur as complex internal and external chemical mixtures, whose physical and chemical natures are difficult to characterize. The aerosol and trace gases interact physically and chemically in a variety of ways. A particular important interaction involving atmospheric oxidants is associated with emissions of precoursor gases and particles in combination with oxidation processes in the gas phase. The challenge before researchers is to formulate a creative and rational method of defining the contribution of aviation-sourced pollutants that impact the watershed. These would be achieved by obtaining specific data on the volume and coordinates of the aviation aerosolized pollutants within the Anacostia River airshed and watershed.

The objectives of the present project include: 1) a comprehensive study of recent works related to the health of the Anacostia River as well as government policies that may impact the revitalization of the Anacostia River. In particular, the construction of the stadium along the River may have unfavorable ecological impact on the health of the River notwithstanding the stated economic benefits. The final report will address the dynamics of this new construction project in relation to the future health and clean-up of the Anacostia River. The National Environmental Trust (NET) provides a summary of major scientific reports on air pollution and public health. The reports include: The Importance of Population Susceptibility for Air Pollution Risk Assessment, Association of Particulate Matter Components with Daily Mortality and Morbidity in Urban Populations, Asthma in Children exposed to Ozone, Effect of Air Pollutants on Acute Stroke Mortality, etc. These and other reports can be found on the NET website at www.net.org ; 2) an objective definition of the airshed that impacts the Anacostia River and its estuaries. Literature survey revealed that considerable work has been done on the definition of the Chesapeake Bay airshed.

The region encompasses a vast area covering hundreds of thousands of square miles. The implication is that airborne pollutants released hundreds of miles from the watershed impact and get deposited in the watershed. However, our survey has not revealed similar body of work that seeks to define the Anacostia River airshed. It is important that the boundary of the airshed be accurately defined in order to model the airports that may impact the Anacostia watershed; 3) an assessment and review of literature pertaining to the source and nature of pollutants in the Anacostia River; 4) an analysis of existing models of airborne pollutants and their deposition mechanisms in the applicable watershed; 5) a presentation or development of alternative and more effective models for defining the load due to both wet and dry deposition caused by air pollution.

Such model will include; the neural modeling of pollution forecasting, application of numerical model to track the diffusion and transport of airborne pollutants, the use of fuzzy logic method to predict the relationship between air pollutants and watershed contamination, and the design of experimental algorithm to validate these various prediction models.

Within the past year, a comprehensive study of recent works related to the health of the Anacostia River and the impact on the surrounding population, as well as, the economic potential of the region has been undertaken. Unlike the substantial progress made in the remediation of the Chesapeake Bay over the past years, the condition of the Anacostia River has not improved. In fact, some studies suggest that the level of its pollution might be getting worse. This situation continues to impact adversely on the health of the surrounding population, especially through contact with the water and consumption of fish from the River. Various government policies and studies conducted over the past decade are summarized and enumerated in a report titled: Anacostia River and Tributaries Maryland and District of Columbia Comprehensive Watershed Plan – Section 905(b) (WRDA 86) Analysis.

These studies have carefully detailed the contaminant load in the River and proposed recommendations to alleviate and remediate the adverse impact on the environment. Several US Environmental Protection Agency (USEPA) studies and reports have detailed the chemical pollutants in the River and their health impact on the population. A USEPA Report titled: How to Measure the effect of Acid Deposition: A Framework for Ecological Assessments provide an assessment of airborne pollution of the Anacostia River. A detailed bibliography and synopsis of these reports will be provided in the final project report. Furthermore, an effort will be made to define the economic and ecological/environmental impact of the new stadium on the River. In particular, an attempt will be made to predict how the project might spur government action to mobilize necessary resources to effect the cleanup of the River.

Any attempt to develop theoretical/computational or experimental models to determine the contribution of airborne pollution to the contamination of the River must rely on an accurate definition of the boundaries of the pollutant “catchments” area, i.e. the airshed. So far our literature search has not revealed any meaningful publications or reports

detailing the Anacostia airshed. However, there are reports that define the Chesapeake Bay airshed. It is the aim of this project, therefore, to replicate the Chesapeake Bay airshed definition analysis to obtain an Anacostia River airshed. Such study would help to delineate the boundary of the region of pollutant emission that would impact the Anacostia watershed.

In addition, we are examining reports pertaining to other bodies of water, such as Lake Michigan. Water pollution in Lake Michigan by trace elements from pollution aerosol fallout authored by J.W. Winchester and G.D. Nifong was published in Water, Air, & Soil Pollution. The paper made a partial inventory of air pollution emissions for 30 trace elements in the Chicago, Milwaukee, and northwest Indiana metropolitan area and compared this with actual stream inputs measured for Zn, Cu, and Ni. The study concluded that the atmosphere may be a major source of Zn and other trace minerals in Lake Michigan. The report calls for more comprehensive chemical data to quantify unpolluted stream inputs for other elements in the Lake. More information is also available in **Deposition of Air Pollutants to the Great Waters, Third Report to Congress, June 2000.**

Efforts are underway to obtain the numerical model used in defining the Chesapeake Bay watershed from the Chesapeake Foundation. The Airshed Model (Regional Acid Deposition Model – RADM) tracks nitrogen emissions from all sources in the airshed. The model is three-dimensional; it stimulates movement both vertically and horizontally across a region. The airborne nutrients loads are transported by the Airshed Model and linked to the Watershed Model through deposition to land surfaces and to the Estuary Model through deposition to the water surfaces of the tidal Bay. In particular, efforts would be focused on the transport of airborne nitrogen and other byproducts of aviation fuel combustion. Computer models revealed that approximately 25% of nitrogen entering the Bay comes from the air.

The Bay airshed was defined as the area where NOx emission sources contribute 76% of the atmospheric deposition to the Bay and its surrounding watershed. Similar assumptions will be made in defining the Anacostia airshed. The Bay airshed is almost 350,000 square miles reaching from Toronto, Canada south to North Carolina and west to Indiana. The airshed configuration changes with continuous refinement and improvement in the computational model. Another challenge facing this present study is how to separate aircraft-induced air pollutants from those from automobiles and industries.

A comprehensive review of literature pertaining to the sources and nature of the chemical pollutants in the Anacostia River is currently underway. This task was assigned to the student member of the project team. The National Atmospheric Deposition Program (NADP) Library provides a wealth of data summaries, data reports, and technical reports focusing on the nature and sources of pollutants in the Anacostia River Watershed. The online database at http://nadp.sws.uiuc.edu/lib/bibsearch.asp contains numerous publications relevant to our problem. Upstream sources include both point and non-point

sources to waters above the fall line. Point sources of organic contaminants (PAHs and PCBs) are highly uncertain.

Urban runoff is a substantial source of select organic contaminants and metals to the Anacostia River. Below the fall line, atmospheric deposition loads increase in areas of the River adjacent to urban areas. It is believed that the regional airports in the Baltimore-Washington metropolitan area, as well as within the airshed contribute to the atmospheric deposition loads. Shipping and boating-related spills result in pollutant loads from jet fuel, gasoline, diesel fuels, asphalt, and PCBs. Pesticide loads to the River are largely unknown. Sources of chemical contaminants loads are dependent on land use characteristics. National Air Quality and Emissions Trends Report, 2000 features comprehensive information for the criteria pollutants and hazardous air pollutants, as well as relevant ambient air pollution information for visibility impairment and acid rain.

The Water Resources Research Journals contain several publications dealing with atmospheric contributions to water quality streams. A report by D.W. Fisher et al, details atmospheric contributions to the Hubbard Brook in New Hampshire. Other journal reports focused on the modeling of the effects of acid deposition, and the estimation of long-term water quality responses in a small forested catchments. The Water, Air, & Soil Pollution Journal carries publications addressing pollutant wet deposition mechanisms in precipitation and fog water; modeling the effects of acid deposition and control of long-term sulfate dynamics; and measuring dry deposition.

Nitrogen has been identified as a major component of airborne water pollutant. Nitrogen: Multiple and Regional Impacts is a 2002 USEPA report that summarizes atmospheric emissions, deposition, and impacts of oxidized nitrogen.

Evaluation of previous work and models on the evolution of air pollutions and the means of introduction to the waterways is underway and should be concluded by the end of July. In particular the Airshed Model developed for the Chesapeake Bay and several air pollution models for major waterways have been examined. The RADM involves 22,000 cells with each cell measuring eighty kilometers square. Stacked up, the cells make fifteen vertical layers reaching about fifteen kilometers high.

Two new models are being presented to compute and simulate the mechanism for the deposition of airborne pollutant in the Anacostia River. The initial effort is focused on delineating the Anacostia airshed. A simplified Navier-Stokes analysis in Cartesian coordinate system will be implemented to simulate the transport/diffusion of a prescribed aerosol distribution under a given ambient atmospheric air flow. The real problem will be solved with accurate aircraft-induced pollutant subject to prevailing atmospheric conditions at different times of the year. Accurate weather data, in particular air movement patterns would have to be obtained from the NOAA. The given airflow data will be used as input to a numerical algorithm to predict the deposition of airborne pollution within the watershed of Anacostia. There are various numerical/computational codes available in the market; these codes will be evaluated for the most appropriate and cost-effective for our problem of interest.

Neural networks, with their remarkable ability to derive meaning from complicated or imprecise data, will be used to extract patterns and detect trends. Once the pollution loads have been defined, a neural network algorithm will be defined to reveal hidden patterns. A Fuzzy-Belief-State-Based Reasoning model has been developed based on similar work by Dr. Liang, one of the project associates. In a real world it is often true that not all of the variables in a state can be observed at a given time. In such cases, the observation data is determined incomplete. Also, the present data contain noise. From an uncertain and incomplete observed input state vector we propose to use fuzzy-belief-sate-base to complete the observation, account for the uncertainty with beliefs, and perform a type of reasoning to select a decision as a response to that input. This process involves fuzzification, data association, belief inferencing, decision retrieval, and decision adjustment. This method can be used to capture evolutionary process whose interrelationships change over time. This will enable the prediction of the relationship between air pollutants and watershed contamination.

Preliminary assessment of experimental investigation using spectrography to monitor air chemistry suggests that one has of find a way to resolve the anomaly created by optical pollution in urban areas that will affect the result of the spectrographic analysis. Air contains molecules and radicals characterized by elements, such as, nitrogen and phosphorus.

At the conclusion of this phase of the project, the team plans to embark on a multi-year effort to perfect the various schemes described above.